FIGURE 1

ADAPTIVE OUTPUT FEEDBACK CONTROL SYSTEM
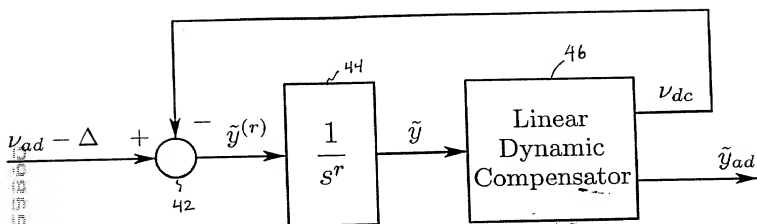
FIGURE 2
Tracking Error Signal Analysis

Block diagram showing: input $\nu_{ad} - \Delta$ into a summing junction (42) with $+$ and $-$ inputs, producing $\tilde{y}^{(r)}$, into block 44 labeled $\dfrac{1}{s^r}$, producing $\tilde{y}$, into block 46 labeled "Linear Dynamic Compensator" with output ν_{dc} feeding back to the summing junction, and output $\tilde{y}_{ad}$.

FIGURE 3

LINEAR DYNAMIC COMPENSATOR (LDC)

FIGURE 4
BOUNDED
ADAPTIVE
ELEMENT
(AE)

16

TIME DELAY ELEMENT

40

52_1
52_{n1-r-1}
54_1
54_{n1-1}

TDL

ν

y

NEURAL NETWORK
ADAPTIVE ELEMENT
(NNAE)

36

64

v

w

56_1
56_2
56_{N1}

$\phi()$

N_1

58_1
58_2
58_{N2}

N_2

ν_{ad}

ϕ

δ

ERROR
CONDITIONING
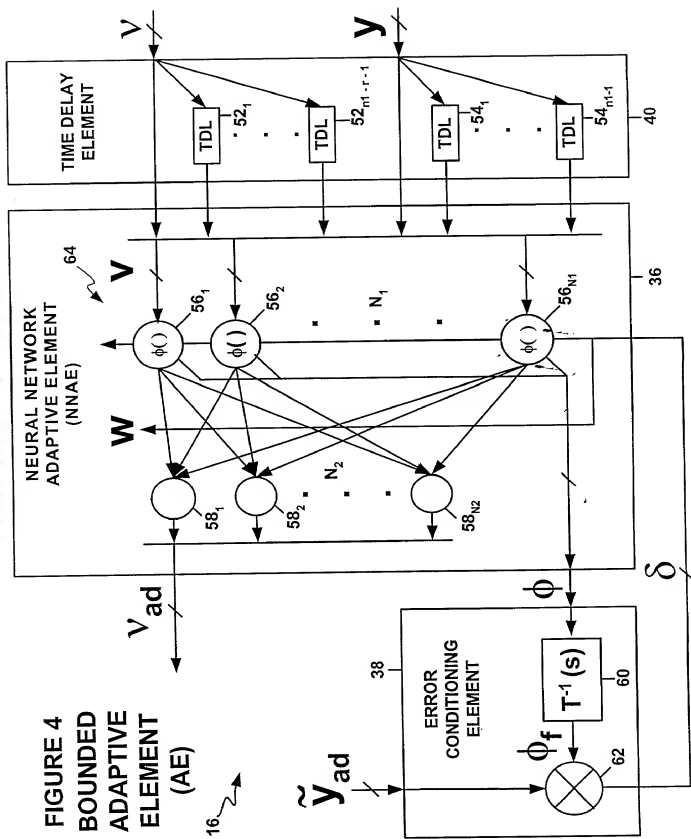ELEMENT

38

$T^{-1}(s)$

60

ϕ_f

62

$\tilde{y}_{ad}$

FIGURE 5

PROCESSOR-BASED ADAPTIVE CONTROL
SYSTEM USING DIRECT OUTPUT FEEDBACK

FIGURE 6

S1 — (START)

S2 — GENERATING COMMAND CONTROL SIGNAL δ_c BY INVERTING AN APPROXIMATE MODEL OF PLANT DYNAMICS, BASED ON PSEUDO-CONTROL SIGNAL ν AND PLANT OUTPUT SIGNAL y

S3 — SUPPLYING THE COMMAND CONTROL SIGNAL δ_c TO CONTROL THE PLANT

S4 — GENERATING A PLANT OUTPUT SIGNAL y

S5 — GENERATING A TRACKING ERROR SIGNAL $\tilde{y}$ BY DIFFERENCING CORRESPONDING SIGNAL COMPONENTS OF THE COMMANDED OUTPUT SIGNAL y_c AND OPTIONAL DERIVATIVES THEREOF, AND A PLANT OUTPUT SIGNAL $\tilde{y}$

S6 — GENERATING A PSEUDO-CONTROL COMPONENT SIGNAL ν_{dc} BASED ON THE TRACKING ERROR SIGNAL $\tilde{y}$

S7 — GENERATING A TRANSFORMED SIGNAL $\tilde{y}_{ad}$ BASED ON TRACKING ERROR SIGNAL $\tilde{y}$

S8 — GENERATING AN R-TH DERIVATIVE OF COMMANDED OUTPUT SIGNAL $y_c^{(r)}$.

S9 — GENERATING A SIGNAL $\tilde{y}_{ad}$ TO RENDER TRANSFER FUNCTION FROM ν_{ad} TO $\tilde{y}_{ad}$ TO BE STRICTLY POSITIVE REAL

S10 — GENERATING A TRAINING SIGNAL δ BY FILTERING BASIS FUNCTION(S) ϕ AND MULTIPLYING THE FILTERED BASIS FUNCTION(S) ϕ BY TRANSFORMED SIGNAL $\tilde{y}_{ad}$

S11 — UPDATING CONNECTION WEIGHTS W OF A NEURAL NETWORK IN A BOUNDED MANNER BASED ON THE TRAINING SIGNAL δ

S12 — GENERATING DELAYED VERSIONS OF PSEUDO-CONTROL SIGNAL ν

S13 — GENERATING DELAYED VERSIONS OF PLANT OUTPUT SIGNAL y

S14 — GENERATING THE ADAPTIVE CONTROL SIGNAL ν_{ad} BASED ON PSEUDO-CONTROL SIGNAL n AND DELAYED VALUES ν_d, PLANT OUTPUT SIGNAL y AND DELAYED VALUES y_d, AND CONNECTION WEIGHT(S) W, V AND BASIS FUNCTION(S) ϕ UPDATED BASED ON TRACKING ERROR SIGNAL δ

S15 — GENERATING A PSEUDO-CONTROL SIGNAL ν BASED ON r-TH TIME-DERIVATIVE OF COMMANDED OUTPUT SIGNAL $y_c^{(r)}$, PSEUDO-CONTROL COMPONENT SIGNAL ν_{dc}, AND ADAPTIVE CONTROL SIGNAL ν_{ad}
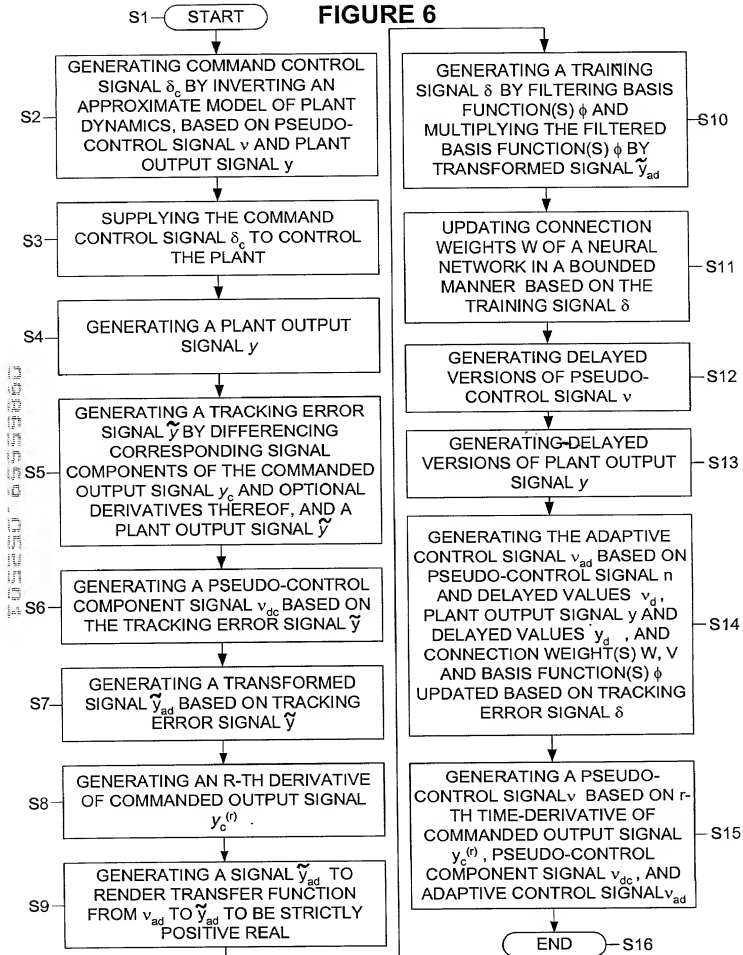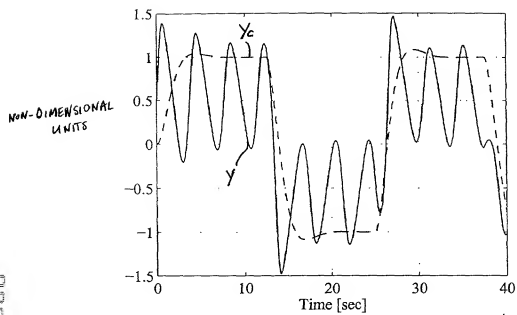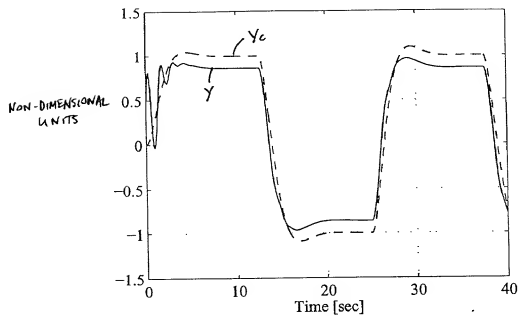
(END) — S16

FIGURE 7

System without unmodelled dynamics: response with linear compensator

FIGURE 8A

NON-DIMENSIONAL UNITS

Y_c

Y

Time [sec]

(a) System tracking

FIGURE 8B

ν_{ad}
Δ

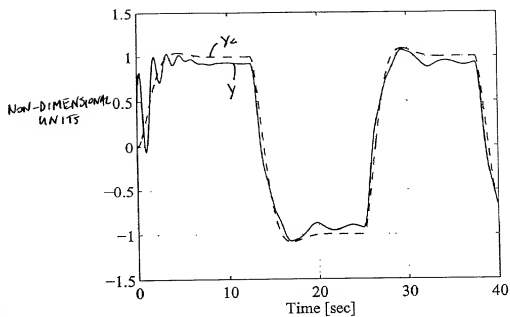NON-DIMENSIONAL UNITS

Time [sec]
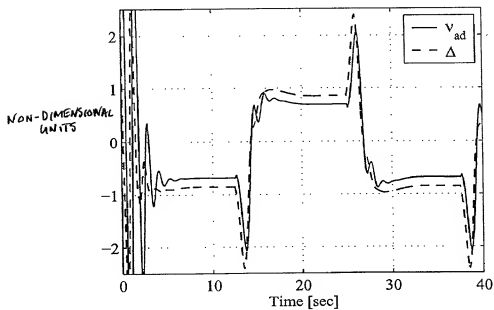
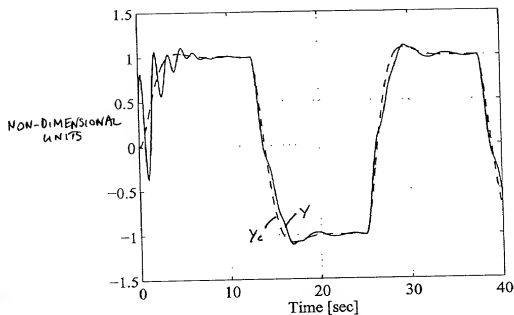(b) NN output ν_{ad} and inversion error Δ

System without unmodelled dynamics and NN controller
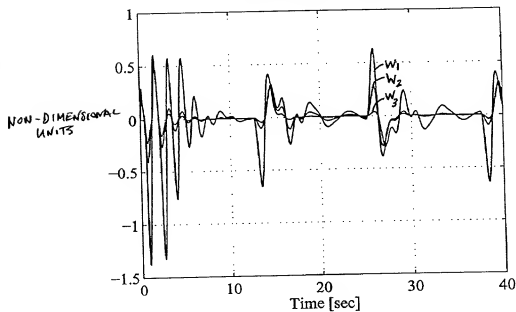
FIGURE 9

System with unmodelled dynamics: response with NN controller

FIGURE 10A

(a) System tracking

FIGURE 10B

(b) NN weight history

System with unmodelled dynamics: response with NN controller and linear compensator